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Impact of Soybean Planting Date on Soil Population Density of *Macrophomina phaseolina*

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Abstract

A field experiment was conducted during 2000-2003 near Portageville, MO to determine the affects of soybean planting date on the soil population density of *Macrophomina phaseolina*. The site was planted to cotton the previous 10 years. The planting dates were mid-April, mid-May, and mid-June during 2000-2003, and the cultivars FFR3975 and Asgrow 3834, maturity group 3, were very susceptible to *M. phaseolina.* Plots were in the same location each year. Soil samples from the top 15-cm soil layer were collected from plots during May 2000-2004 and analyzed for the population density of *M. phaseolina*. Planting date did not affect the soil population density of *M. phaseolina*, but the differences in soil population density among years were significant. These results suggest that soybean producers should not be concerned about planting date directly affecting *M. phaseolina* soil population densities.

Introduction

Charcoal rot, caused by *Macrophomina phaseolina* (Tassi) Goidanich, is a common disease in many parts of the world. This pathogen is distributed widely and attacks many different plant species including soybean (*Glycine max* L.) (15). Charcoal rot suppresses soybean yield in many areas of the world and ranked third among economically important soybean diseases in the top ten soybean producing countries during 1998 (16). This disease ranked within the top ten among economically important soybean diseases in the US during 2003-2005 (19). Estimates of yield reduction due to charcoal rot in the US were 1.98, 0.28, and 0.49 million metric tones in 2003, 2004, and 2005, respectively. Differences in soybean yield suppression due to charcoal rot among years are due to differences in the environment with yield suppression due to this disease increasing with drought (15).

Fig. 1. Lower soybean stem discoloration due to *Macrophomina phaseolina* colonization.

Fig. 2. Soybean plants damaged and killed by charcoal rot.

Management strategies for charcoal rot of soybean are very limited, and these strategies do not completely protect soybean against *M. phaseolina*. Charcoal rot resistant cultivars and lines (genotypes) are not available. There is variation among soybean genotypes in rate of root tissue colonization by *M. phaseolina* (3,8,12), and the few genotypes that resist or retard root colonization by this pathogen sometimes yielded greater than genotypes that did not resist root colonization. Recently, Paris et al (11) released a genotype they rated moderately resistant to charcoal rot, but genotypes with more resistance are needed. Other charcoal rot management strategies are plant cultural methods to minimize drought stress such as reduced plant populations, management of planting dates, and cultivar selection to avoid mid-season drought stress (2) and irrigation (8). Tillage did not affect *M. phaseolina* soil population density in the upper 15-cm layer of soil, and soybean root infection rates were similar among tillage treatments (1,17). Cotton and corn are hosts of this pathogen, but a 3-year rotation with cotton caused the soil population density of this pathogen to decline (5), and a 3-year rotation with corn reduced soybean root colonization by *M. phaseolina* (10). Planting date can affect the severity of some soybean diseases such as sudden death syndrome (7) and Phomopsis seed decay (18), and affect the soil population density of *Heterodera glycines* (13). Smith and Carvil (14) determined that planting date affected the population density of *M. phaseolina* in R7 stage soybean root and lower stem tissue, but they did not determine if this resulted in differences in soil population density of *M. phaseolina*. The objective of this study was to determine if planting date affected soil population densities of *M. phaseolina*.

Impact of Planting Date on *Macrophomina phaseolina* Soil Population Density

An experiment was established in 2000 to 2003 near Portageville, MO to determine the affects of soybean planting date on soil population density of *M. phaseolina*. The soil was a sandy loam with 6.3% clay, 37.2% silt, and 56.5% sand, and the field had been planted to cotton the ten previous years. Prior to planting soybean each year, the field was disked twice, and row beds (75-cm or 38-inch spacing) were formed. The top 10 cm of the beds were pushed off just prior to planting to form a flat-top ridge. University of Missouri Extension recommended agronomic practices were used for weed control and fertilization. Each four-row plot was 10 m long with 5-m alleys between plots to prevent movement of soil and plant residue among plots during tillage. Plots were in the same location each year, rows were planted over the previous years, and plots were not irrigated. Yield and disease severity data were not collected.

A randomized block experimental design with four replications was employed to evaluate three planting dates. Planting dates were mid-April, mid-May, and mid-June in all years. The cultivar FFR 3975 was planted during 2000-2002, and Asgrow 3834 was planted in 2003. These cultivars were selected because they were very susceptible to *M. phaseolina* in previous field trials. Each cultivar was planted at 26 seeds/m.

Soil samples were collected from within row of each plot in May each year to determine microsclerotial soil populations (17). Samples were collected at that time because soil population densities peak after crop residue from the previous crop decomposed (5). Ten soil cores were collected from within the two center rows of each plot, and these cores (2.5 cm diameter × 15 cm deep) were bulked. Soil samples were allowed to dry on a laboratory bench and then passed through a 45-µm-mesh sieve. A 5-g portion of the sieved soil was suspended in a 500-ml flask containing 250 ml of 0.5% sodium hypochlorite. The flask containing the suspension was placed on a rotating shaker (120 cycles per min) for 10 min. The suspension was then poured onto a 325-µm-mesh sieve, and the debris was rinsed with tap water for 30 sec. The residue on the sieve was transferred to a 250-ml flask, and 100 ml of the selective medium Cholorneb-Mercury-Rose Bengal agar (CMRB) was added. The suspension was gently swirled and then divided among five petri plates. The petri plates were incubated in the dark at 33°C for 5 to 7 days. Microsclerotia densities were calculated from the number of colony-forming units on the plates and adjusted to a per gram of dried soil basis. Data were log transformed, and ANOVA was used to analyze all data, and mean separation was by an *F* test protected LSD (9). SAS (SAS Institute, Cary, NC) was used for all analyses. Data on charcoal rot symptoms on stems and foliage were not collected.

Soybean planting date did not affect soil population density of *M. phaseolina* (Table 1). Smith and Carvil (14) determined that a May compared to June planting date resulted in significantly greater population density of *M. phaseolina* in lower stem and root tissue of some R7 growth stage soybean cultivars but not all. They did not determine the population density in tissue at the R8 growth stage or soil population density the following spring after the soybean residue decomposed. Planting date did not affect *M. phaseolina* infection of muskmelon or charcoal rot symptom expression in muskmelon (4). The affects of planting date on soybean yield suppression due to *M. phaseolina* are not known.

Table 1. Analysis of variance for soil population density of *Macrophomina phaseolina* (log cfu/g soil) for planting dates and years.*

Source of variation	***Pr* ≥ F**
Year (Y)	.0001
Plant date (PD)	0.4329
PD × Y	0.1492

* Years were 2000-2004, and planting dates were mid-April, mid-May, and mid-June. Soil samples were collected within row during May each year.

The affects of soil population densities of *M. phaseolina* at planting time on soybean health are not clear. There was a positive correlation between soil population densities of *M. phaseolina* at planting and soybean seedling injury (3). However, soil population density was correlated with soybean yield only one of two years in Missouri (5) and not during a three year study in Tennessee (17).

Our results indicate that planting date manipulation will not be an effective tool for managing soil population density of *M. phaseolina*, and producers that have adopted the Early Soybean Production System (6) should not be concerned about this system directly affecting the soil population density of this pathogen. However, planting date manipulation is an affective tool for avoiding soybean drought stress, and since drought stress enhances yield suppression due to charcoal rot, planting date selection to minimize drought stress may be indirectly useful for protecting soybean against charcoal rot.

Soil population densities of *M. phaseolina* during May varied among years (Table 2). The soil population was lowest in May 2000 probably because this test site was planted to cotton the ten previous years (5). The population for May during 2001 and 2002 was significantly greater than for May 2000, 2003, and 2004. These differences in soil population density of *M. phaseolina* during May among years may have been due to effects of drought on colonization of soybean by this pathogen. Drought in July-August was severe during 2000 (74 mm of

rain) and 2001 (66 mm of rain), was less severe in 2002 (88.9 mm of rain), and did not occur during 2003 (114 mm of rain). Drought impacted the average soybean yield for the county where this test was conducted; average yields for Pemiscot Co. were lowest in 2000 (1545 kg/ha or 23 bu/acre) and 2001 (1949 kg/ha or 29 bu/acre), greater in 2002 (2096 kg/ha or 31 bu/acre), and greatest in 2003 (2620 kg/ha or 39 bu/acre).

Table 2. Year effects on soil population density of *Macrophomina phaseolina* (log cfu/g soil) averaged over planting date.*

Year	Soil population density
2000	3.63 c
2001	5.06 a
2002	5.26 a
2003	4.66 b
2004	4.79 b

* Planting dates were mid-April, mid-May, and mid-June. Soil samples were collected within row during May each year.
Means followed by the same letter are not significantly different (P=0.05).

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Literature Cited

1. Almeida, A. M. R., Saraiva, O. F., Farias, J. R. B., Gaudencio, C. A., and Torres, E. 2001. Survival of pathogens on soybean debris under no-tillage and conventional tillage systems. Pesq. Agropec. Bras. 36:1231-1238.
2. Bowen, C. R., and Schapaugh W. T. 1989. Relationships among charcoal rot infection, yield, and stability estimates in soybean blends. Crop Sci. 29:42-46.
3. Bristow, P. R., and Wyllie, T. D. 1984. Reaction of soybean cultivars to *Macrophomina phaseolina* as seedlings in the growth chamber and field. Trans. MO Acad. Sci. 18:5-10.
4. Bruton, B. D., Hartz, T. K., and Cox, E. L. 1985. Vine decline in muskmelon as influenced by cultivar and planting date. HortScience 20:899-901.
5. Francl, L. J., Wyllie, T. D., and Rosenbroch, S. M. 1998. Influence of crop rotation on population density of *Macrophomina phaseolina* in soil infested with *Heterodera glycines*. Plant Dis. 72:760-764.
6. Heatherly, L. G., and Elmore, R. W. 2004. Managing inputs of peak production. Pages 451-536 in: Soybeans: Improvement, Production, and Uses, 3rd Ed. H. R. Boerma and J. E. Specht, edss ASA-CSSA-SSSA, Madison, WI.
7. Hershman, D. E., Hendrix, J. W., Stuckey, R. E., Bachi, P. R., and Henson, G. 1990. Influence of planting date and cultivar on soybean sudden death syndrome in Kentucky. Plant Dis. 74:761-766.
8. Kendig, S. R., Rupe, J. C., and Scott, H. D. 2000. Effect of irrigation and soil water stress on densities of *Macrophomina phaseolina* in soil and roots of two soybean cultivars. Plant Dis. 84:895-900.
9. Little, T. M., and Hills, F. J. Agriculture Experimentation. John Wiley & Sons, New York.
10. Mueller, J. D., Shortt, B. J., and Sinclair, J. B. 1985. Effects of cropping history, cultivar, and sampling date on the internal fungi of soybean roots. Plant Dis. 69:520-523.
11. Paris, R. L., Mengistu, A., Tyler, J. M., and Smith, J. R. 2006. Registration of soybean Germplasm Line DT97-4290 with moderate resistance to charcoal rot. Crop Sci. 46:2324-2325.

12. Pearson, C. A. S., Schwenk, F. W., and Crowe, F. J. 1984. Colonization of soybean roots by *Macrophomina phaseolina*. Plant Dis. 68:1086-1088.
13. Riggs, R. D., Wrather, J. A., Mauromoustakos, A., and Rakes, L. 2000. Planting date and soybean cultivar maturity group affect population dynamics of *Heterodera glycines*, and all affect yield of soybean. J. Nematol. 32:334-342.
14. Smith, G. S., and Carvil, O. N. 1997. Field screening of commercial and experimental soybean cultivars for their reaction to *Macrophomina phaseolina*. Plant Dis. 81:363-368.
15. Smith, G. S., and Wyllie, T. D. 1999. Charcoal rot. Pages 29-31 in: Compendium of Soybean Diseases, 4th Ed. G. L. Hartman, J. B. Sinclair, and J. C. Rupe, eds. American Phytopathological Society, St. Paul, MN.
16. Wrather, J. A., Anderson, T. R., Arsyad, D. M., Tan, Y., Ploper, L. D., Porta-Puglia, A., Ram, H. H., and Yorinori, J. T. 2001. Soybean disease loss estimates for the top ten soybean-producing countries in 1998. Can. J. Plant. Pathol. 23:115-121.
17. Wrather, J. A., Kendig, S. R., and Tyler, D. D. 1998. Tillage effects on *Macrophomina phaseolina* population density and soybean yield. Plant Dis. 82:247-250.
18. Wrather, J. A., Kendig, S. R., Wiebold, W. J., and Riggs, R. D. 1996. Cultivar and planting date effects on soybean stand, yield, and *Phomopsis* sp. seed infection. Plant Dis. 80:622-624.
19. Wrather, J. A., and Koenning, S. R. 2006. Estimates of disease effects on soybean yields in the United States 2003-2005. J. Nematol. 38:173-180.